CLAIMS

1. A method for time-phase entanglement quantum key distribution comprising:

a) at a photon transmitter, generating with a regulated single-photon generator a pair of photons separated in time by a predetermined delay Δt; and coherently splitting each of the photons into two components of a coherent superposition;

b) transmitting the two components of each photon, respectively, to two receivers;

c) at the two receivers, generating from each component of each photon a coherent superposition of time-shifted states having a relative time shift of Δt; detecting the photons with single-photon detectors; and deriving part of a quantum key from detector information and time slot information associated with the detecting.

2. The method of claim 1 wherein the photons of the pair are generated with random relative phase.

3. The method of claim 1 wherein the photons are quantum-mechanically indistinguishable by the detectors.

4. The method of claim 1 wherein the receivers have polarization-independent operation.

5. The method of claim 1 wherein a beat frequency difference Δf between the photons is small enough that a period corresponding to Δf is large compared to a pulse width of the photons.

6. The method of claim 1 wherein Δt is larger than a pulse width of the first photon and larger than a pulse width of the second photon.

7. The method of claim 1 wherein Δt is 1 ns or less.

8. The method of claim 1 further comprising synchronizing the transmitter and two receivers to a common time-reference.

9. A time-phase entanglement quantum key distribution system comprising:

a) a photon pair source comprising a regulated single-photon generator for sequentially generating two photons of a pair, wherein the two photons have random relative phase and are separated by a predetermined time interval Δt, and an optical coupler for coherently splitting each of the two photons into two coherent components of a coherent superposition;

b) two optical transmission lines coupled to the photon pair source for transmitting, respectively, the two coherent components of each of the two coherently split photons; and

c) two receivers coupled, respectively, to the two optical transmission lines, wherein each of the receivers comprises and interferometer having two arms with relative optical path difference substantially equal to the time interval Δt, and a pair of single-photon detectors coupled to each interferometer.

10. The system of claim 9 wherein the regulated single-photon generator comprises a quantum dot embedded in a micro-cavity.

11. The system of claim 9 wherein the regulated single-photon generator is implemented using color centers in diamond.

12. The system of claim 9 wherein the regulated single-photon generator comprises a time synchronization pulse transmitter.

13. The system of claim 9 wherein the interferometer comprises a glass waveguide circuit.

14. The system of claim 9 wherein the interferometer comprises a phase rotator.

15. The system of claim 9 wherein the detectors comprise InGaAs/InP avalanche photodiodes.

16. A time-phase entanglement photon pair source comprising:

a) a regulated single-photon generator for sequentially generating two photons of a pair, wherein the two photons have random relative phase and are separated by a regulated time interval Δt; and

b) an optical coupler for coherently splitting each of the two photons into two coherent components directed, respectively, to two receivers.

17. The photon pair source of claim 16 wherein the regulated single-photon generator comprises a quantum dot embedded in a micro-cavity.

18. The photon pair source of claim 16 wherein the regulated single-photon source is implemented using color centers in diamond.